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# RESEARCH PROBLEMS

**Problem 95.** Posed by Brian Alspach and Haluk Oral.

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Let $A$ be an independent set of vertices in a graph $G$. Let $C(A)$ be the collection of all connected induced subgraphs of $G$ which contain $A$. Define

$$\omega(A) = \min\{|E(H)| - |V(H) + 1 : H \in C(A)\}.$$

What can be said about $\omega(A)$ for various classes of graphs? Of particular interest are the cases when $A$ is a maximal independent set of vertices in $G$ or $A$ is a color class in a proper vertex coloring of $G$ with chr($G$) colors, where chr($G$) denotes the chromatic number of $G$.

**Problem 96.** Posed by D. de Caen.

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Let $G$ be a graph embedded in the plane. A facial factor of $G$ is a 2-factor (a spanning 2-regular subgraph), each of whose connected components is the boundary of some face of $G$. Find non-trivial necessary and sufficient conditions for the existence of a facial factor in a plane graph $G$.

An obvious necessary condition is that $G$ have a 2-factor. Such graphs were characterized by Tutte. On the other hand, any embedding of $K_4$ has a 2-factor but no facial factor. In a personal correspondence, Carsten Thomassen has made some observations on the computational complexity of finding a facial factor for a plane graph.